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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

COSTICH LAKE BASIN
COSTICH DAM
EUREKA, MONTANA
MT-1025

PREPARED FOR:

THE HONORABLE TED SCHWINDEN
GOVERNOR OF THE STATE OF MONTANA

GLEN LAKE IRRIGATION DISTRICT
(OWNER AND OPERATOR)

PREPARED BY:

MORRISON - MAIERLE, INC.

CONSULTING ENGINEERS

JUNE, 1981

U.S. ARMY CORPS OF ENGINEERS
Seattle DISTRICT

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EXECUTIVE SUMMARY

Under contract with the Montana Department of Natural Resources and Conservation and with representation from the Department of Natural Resources and Conservation and the Glen Lake Irrigation District, Morrison-Maierle, Inc. inspected Costich Dam on 24 July 1980 under the authority of Public Law 92-367. The dam is located in Lincoln County about one mile east of Eureka, Montana in a small natural lake basin with no defined tributary.

This report was compiled from information obtained during onsite inspection, review of construction plans, and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

Costich Dam is an off-stream storage project owned and operated by the Glen Lake Irrigation District. The dam and reservoir were designed by the U.S. Soil Conservation Service for storage and regulation of irrigation waters. The reservoir is impounded by a 24.4-foot high earth dam and by the banks of the Glen Lake supply canal (main canal) which forms the west boundary of the lake. The top of the canal bank, elevation 2848.2 National Geodetic Vertical Datum (NGVD), is actually lower than the dam crest elevation 2850.3 feet NGVD. Approximately 470 acre-feet of water is impounded at the top of the canal bank and 570 acre-feet would be impounded at the dam crest elevation if the reservoir could attain that height. The principal spillway for the project is an uncontrolled riser pipe discharging to the low level outlet pipe. There is no emergency spillway for the project. All elevations used in this report are based on assumed elevation 2847.0 feet at the top of the principal spillway riser pipe which corresponds to a project datum elevation of 214.0 feet on the construction plans.

On the basis of criteria in U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Reference 1), the project is small in size. The dam is located such that its failure would endanger approximately five houses and several mobile homes and commercial structures. However, no dam breach analysis or routing of a dam breach flood was made for the downstream area. The conclusions on probable damage are based on a brief field visit and engineering judgement.

The project is classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Reference 1) recommend that a small size project with a high downstream hazard potential be capable of safely handling from one-half the probable maximum flood (PMF) to the full PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Based on the finding of this inspection, the full PMF is recommended as the spillway design flood (SDF) because of the high risk to more than two inhabitable structures located downstream.

An estimated thunderstorm PMF was developed for the 0.5 square-mile drainage basin during this dam safety study. The PMF resulting from the 6-hour thunderstorm has an estimated volume of 248 acre-feet and a peak flow of 3,330 cfs. The principal spillway has a maximum discharge capacity of 82 cfs. with the reservoir at assumed top of dam, elevation 2850.3 feet. The project has no emergency spillway. Because the Glen Lake canal bank along the reservoir is lower than the dam, the reservoir will overtop the canal under extreme flood conditions preventing overtopping of the dam.

For the purpose of the hydraulic flood routing analysis of the reservoir, a rating of the flows that would discharge from the reservoir over the canal bank was developed at two locations where the bank is lowest. The total discharge capacity over the canal bank and through the principal outlet is 2100 cfs with the reservoir at the dam crest. The routing of the PMF, beginning with the reservoir at the principal spillway crest, indicates that the canal bank adjacent to the dam is overtopped when approximately 31 percent of the total flood volume enters the reservoir. A flood with a hydrograph having ordinates corresponding to 35 percent of the PMF ordinates is just controlled by the dam and canal bank. Larger floods would overtop the canal embankment adjacent to the dam and endanger the left abutment of the dam. The dam and main canal embankment are constructed of materials that would quickly erode and rapidly fail when overtopped by floodwaters. Such failure could endanger lives immediately downstream and at Eureka and cause extensive damage to streets, roads, property and buildings.

Available information is not adequate to determine embankment stability.

On the basis of the field inspection and study of hydrologic data, Costich Dam project does not now conform to Corps guidelines with respect to discharge and/or storage capacities to safely handle the recommended spillway design flood.

RECOMMENDATIONS

A downstream warning plan, for use in the event of possible dam overtopping or structural failure, needs to be developed and immediately placed in action. Inspect the outlet works and conduit and perform necessary maintenance and repairs. Remove trees and brush on the reaches of the canal embankment which serve as a dam embankment and backfill and compact disturbed areas including major animal burrows.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity and modify the project as studies indicate. Investigate and monitor the observed seepage and determine the phreatic surface in the dam and canal embankments by the installation and monitoring of piezometers. Conduct field exploration and laboratory testing of foundation and embankment soils, to evaluate embankment stability and modify the project as studies indicate. Inspections of the project at 5-year intervals should be conducted by geotechnical engineers experienced in dam design and construction.

Prior to performing engineering studies and remedial construction, coordinate the work with the Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

Rodger C. Foster
Professional Engineer

COSTICH DAM

Pertinent Data

1. GENERAL

Federal ID No.	MT-1025
Owner	Glen Lake Irrigation District
Operator	Glen Lake Irrigation District
Date Constructed	1956
Purpose	Irrigation
Location	Section 12, T36N, R27W Latitude, 48°53'04" Longitude 115°01'20"
County, State	Lincoln County, Montana
Watershed	Costich Lake
Size	Small
Downstream Hazard Potential	Category 1 (High)
USGS Quadrangle	Eureka North, Montana

2. RESERVOIR

Surface Area at Principal Spillway Crest	44.1 acres
Drainage Area	0.5 square miles
Storage at Principal Spillway Crest (Elevation 2847.0 feet NGVD, 214.0 feet project datum)	416 acre-feet
Storage at Crest of Glen Lake Canal (Elev. 2848.2 feet NGVD)	470 acre-feet
Storage at Dam Crest (Elev. 2850.3 feet NGVD)	570 acre-feet
Surcharge Storage from Principal Spillway to Top of Canal	54 acre-feet

3.	EMERGENCY SPILLWAY	None
4.	OUTLET WORKS PRINCIPAL SPILLWAY	
	Conduit	30-inch diameter Corrugated Metal Pipe with 36-inch diameter riser pipe.
	Conduit Length	141 feet
	Gate	30-inch diameter slide gate
	Capacity with reservoir at crest of dam, slide gate fully opened and riser pipe inlet blocked off	82 cfs
5.	DAM	
	Type	Earthfill
	Length	215 feet
	Crest Width	8 to 10 feet
	Crest Elevation	2850.3 feet NGVD 217.3 feet project datum
	Hydraulic Height (Crest to Toe)	24.4 feet
	Upstream Slope	1V on 3H
	Downstream Slope	Varies 1V on 3H to 1V on 2H

Chapter 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Costich Dam, owned by Glen Lake Irrigation District.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federally owned dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigation and evaluation of existing dam conditions, so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is

(1) a limited investigation to assess the general safety condition of the dam.

(2) based upon an evaluation of the available data and a visual inspection.

(3) performed to determine if any needed emergency measures and/or if additional studies, investigations, and analyses are necessary or warranted.

(4) not intended to include extensive explorations and analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases, the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigation outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-federal interests.

1.1.3 Inspection

The findings and recommendations in this report are based on a brief visual inspection of the project and discussions with Mr. William Vanleishout, the ditch rider and dam operator for the Glen Lake Irrigation District. Inspection procedures and criteria are those established by the Recommended Guidelines for Safety Inspection of Dams (Reference 1).

Personnel present during the inspection included:

Larry Tegg	Montana Department of Natural Resources and Conservation
Rodger Foster	Team Leader, Morrison-Maierle, Inc. Water Resource Engineer
Mike Kaczmarek	Engineering Geologist, Morrison-Maierle, Inc.

Mr. William Vanleishout accompanied the inspection team to the dam site and provided introductory information. He did not remain for the inspection.

Additional Morrison-Maierle personnel who contributed to the evaluation are:

Bill Keith	Structural Engineer

Ken Salo Hydrologist/Hydraulics Engineer.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Costich Dam and Reservoir is located in Lincoln County, Montana approximately one mile east and upstream of the town of Eureka (Plates 1 and 2). The project's federal identification number is MT-1025. The dam and reservoir are located in a glacial pothole which has no natural feeder stream. The dam and reservoir are part of the Glen Lake Irrigation project and is supplied by a main canal from Glen Lake located approximately 2½ miles to the southeast. The 24-foot high earthfill dam impounds approximately 570 acre-feet of water at the dam crest, assumed elevation 2850.3 feet NGVD. All elevations in this report are based on an assumed elevation of 2847 feet NGVD at the top of the principal spillway riser pipe which corresponds to a project elevation of 214.0 feet (see plate 4).

Based on visual reconnaissance and engineering judgment approximately five houses, several mobile homes, and some commercial structures would be affected by a sudden breach of Costich Dam. On the basis of this information and in accordance with recommended guidelines, the project size is classified small and the downstream hazard potential is high (category 1).

The project consists of a 215-foot long, 24-foot high dam which impounds the reservoir, and a main canal from Glen Lake which supplies the reservoir. The main canal follows the west shore of the reservoir and, at some locations where natural low divides exist, the canal embankment actually forms a low levee which increases the reservoir capacity beyond what the natural topography would allow (see plates 3 and 4).

The low level outlet and the principal spillway are combined into a single outlet conduit located approximately 110 feet from the east abutment (See Plate 4). The outlet conduit is a 30-inch diameter corrugated metal pipe (CMP). The flow is controlled by a 30-inch diameter slide gate located in the inlet structure at the toe of the upstream slope. The principal spillway is a 36-inch diameter, corrugated-metal, vertical riser pipe located 26 feet upstream of the centerline of the dam. The riser connects to the outlet conduit as an uncontrolled drop inlet (See plate 4). There is no emergency spillway for the project.

1.2.2 Regional Geology and Seismicity

The Costich Dam and Reservoir are located in the northwest corner of Montana in the Rocky Mountain physiographic province (Fenneman, 1931, Reference 2). The area is characterized by high, rugged northwest-trending mountain ranges separated by narrow valleys. Tributaries of the upper Columbia River drainage system occupy the narrow, linear valleys.

The linear valleys are floored with substantial thicknesses of glacial deposits including drumlins, kame terraces, till, and outwash. Late Wisconsin Cordilleran ice advanced over the area from British Columbia and covered

the valley floors with ice ranging in thickness from about 4,000 feet at the International Boundary to at least 2,000 feet near Kalispell. Lacustrine silts and clays from Glacial Lake Missoula are present as far north as Eureka, near Costich Reservoir, but are not present at elevations as high as Costich Reservoir.

Bedrocks underlying the glacial deposits and comprising the mountain ranges consist of late Precambrian Belt Series fine-grained clastic and carbonate rocks. The Belt Series rocks are 17,000 to 40,000 feet thick (Johns, 1970, Reference 3) and have undergone regional low-grade metamorphism. The major valleys are structural troughs bounded by large faults that strike between north and northwest and are parallel or subparallel to structural folds.

In accordance with the Guidelines Seismic Zone Map (Reference 1), the Costich Reservoir and Dam are in Seismic Zone 2. The seismic probability associated with Zone 2 is for moderate earthquake damage and is based on known distribution of damaging earthquakes. Available information regarding the Costich Dam embankment is not adequate to determine whether or not the embankment satisfies design criteria for stability in Zone 2.

1.2.3 Site Geology

Costich Reservoir occupies the site of the former Costich Lake, a small glacial kettle. The capacity of the former Costich Lake was increased by construction of Costich Dam. The entire reservoir and dam area at the Costich site is founded on glacial till. The glacial till consists of a light gray, very dense, compact, friable clay of low plasticity. The clay contains considerable intermixed silt and sand as well as sparse gravels, cobbles, and boulders as observed in local outcrops. The few limited exposures of the till near Costich Dam exhibit distinct signs of crude horizontal stratification. The density of the undisturbed till below the zone of soil weathering and the known history of loading by at least 2,000 feet of ice indicate the undisturbed, unweathered glacial till is preconsolidated.

The foundation and both abutments of the Costich Dam consist of the dense glacial till. The Soil Conservation Service drawings of the dam (Plate 4) state in reference to the foundation materials:

> "Borings at dam site show up to 3' of dark colored gravelly silty clay loam. Below that is a very deep silty clay with some small rocks. No gravel or sand was found. Core trench to be 3 feet deep backfilled with compacted impervious materials."

The "dark colored gravelly silty clay loam" described in the uppermost three feet of the undisturbed foundation material is the shallow pedological soil profile development on the surface of the till and on shallow alluvium-colluvium reworked from the till. The "very deep silty clay" is relatively unweathered and undisturbed till. All observations of the undisturbed till indicate it to be a relatively impervious material. However, the upper three

to four feet of the till exhibits distinct pedological soil development, is considerably less dense than the fresh till, and appears to be somewhat more pervious.

The glacial till supports a rolling topography consisting of northwest-southeast aligned drumlins. The steepest slopes supported by the glacial till are about 16 degrees (1V on 3.5H). Some slopes display slight catsteps indicative of shallow soil creep and other slopes display shallow slump failures. One small shear slump (circular arc failure) borders Costich Reservoir in the NE¼ SW¼ NW¼ of section 18. All of the small slumps appear to be confined to the zone of soil development and are usually closely related to areas receiving irrigation tailwaters, ditch overflows, or overland flow from irrigated fields.

1.2.4 Design and Construction History

Costich Dam was designed by the Soil Conservation Service in 1955 for the Glen Lake Irrigation District and constructed in 1956. It is not known who constructed the dam and there are no construction logs or notes available.

The only information available which describes the design and investigative information for the dam consists of two sheets of design drawings. The quality of the available copies of the design drawings was too poor to allow reproduction for this report. The pertinent details and information from these drawings have been redrafted and are presented on Plates 3 and 4. Some notes on the design drawings refer to foundation borings and foundation preparation. There is no information on shear strength of foundation or embankment materials and there is no seepage analysis on file.

The onsite inspection revealed that an additional embankment not indicated on the design drawings had been placed on the downstream slope of the dam. A personal communication with Mr. Walters, the area conservationist with the SCS, indicates the added embankment was placed as a lower bench to support an irrigation ditch which crosses the dam face. This ditch is not part of the Costich Dam project. It is not known if the bench was placed at the time of the original dam construction or at a later date. Mr. Walters first observed the dam in the early 1960's and the bench was in place at that time. Also, no details or information exist for the main supply canal, which forms a levee along portions of the west reservoir shoreline.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Emergency Spillway and Main Canal

2.1.1.1 Emergency Spillway

Costich Dam has no emergency spillway. The original design drawings refer to this fact in a note which states:

> "Reservoir will be filled from main canal. No spillway needed since there is practically no drainage area."

Even though the project has no emergency spillway, the main canal (Glen Lake Canal) embankment, which forms the west edge of the reservoir, is as much as two feet lower than the crest of the dam, and would be overtopped before the dam.

2.1.1.2 Main Canal

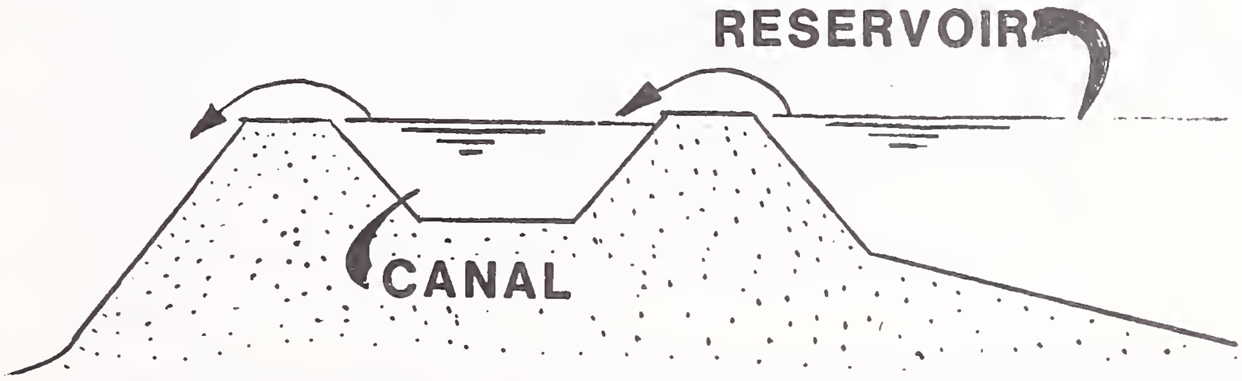
The main canal supplies water from Glen Lake. The canal forms the west bank of the reservoir and in areas of low topography the canal is contained within an embankment fill. The capacity of the canal is approximately 200 cfs; however, the flow from Glen Lake is limited to about 80 cfs due to the capacity of the St. Clair Creek siphon (plate 2). During the inspection, elevations of the canal banks were obtained at two locations. The first section of canal (Reach 1) extends 400 feet south from the west (left) abutment of the dam. In that reach the canal bank elevation varies approximately two feet from elevation 215.2 feet to 217.0 feet project datum (elevation 2848.2 feet to 2850.0 feet NGVD). Flow over the canal bank at this reach would flow around the west abutment of the dam and discharge along the downstream abutment contact area. The area of overflow in the first reach is shown in photos 7, 8 and 9 and on plate 3. Major flows in this area could erode the west abutment threatening the stability of the dam.

A discharge rating curve for overflow of the first reach was developed assuming a weir overflow over the canal bank without bank failure although failure would probably occur. Flow in the overbank area around the dam was computed using a standard step backwater calculation (HEC-2, Reference 4). Using a Manning's "n" value of 0.032, the maximum overflow which would occur at the first reach of the canal was estimated to be 800 cfs with the reservoir at the top of the dam elevation 217.3 project datum. The elevation discharge curve for this overflow is shown on plate 5.

The second reach of canal which was evaluated for overtopping is located approximately 750 feet to 1150 feet upstream of the dam as measured along the canal. This section of the canal bank is also lower than the crest of the dam and varies approximately two feet from elevation 215.2

feet to over 217.0 feet project datum (elevation 2848.2 feet to 2850.0 feet NGVD). Flow overtopping the canal in this area (Reach 2 on plate 3) would discharge to a low depression area and down a separate drainage located immediately west of the reservoir. Flow over the canal bank in this second reach would not threaten the safety of the dam but would cause the main canal to erode resulting in the release of reservoir water down the west drainage. A discharge rating curve for overflow of the second reach was developed assuming a weir overflow of the canal bank again without failure. Using a Manning's "n" value of 0.032, the maximum overflow which would occur at the second reach of canal was estimated to be 1200 cfs. with the reservoir at the top of the dam elevation 217.3 feet project datum (elevation 2850.3 feet NGVD). The elevation-discharge curve for the overflow at the second reach of the canal is shown on plate 5.

For purposes of the safety evaluation the main canal was assumed to be flowing full as it passed along the west bank of the reservoir. During a PMF, sufficient runoff from a small area (0.04 square miles or approximately 26 acres) north of St. Clair Creek and along with some initial overflow from the Costich Reservoir at the upper diversion and lower turnout, would contribute to the Glen Lake diversions creating a full flow condition in the canal (see plate 3). Therefore, additional water flowing from Costich Reservoir would cause the canal banks to overtop.



2.1.2 Outlet/Principal Spillway

The low level outlet works and the principal spillway for Costich Dam are located at approximately 110 feet from the east abutment and share a common outlet conduit. The principal spillway consists of a 36-inch diameter corrugated metal pipe riser which extends vertically through the embankment about 26 feet upstream of the axis of the dam connecting to the outlet conduit as a drop inlet as shown on plate 4. The principal spillway is an uncontrolled orifice with an iron grate with approximately a one inch mesh. The grate will prevent debris from entering the outlet but debris could clog the drop inlet restricting its capacity. The top of the riser pipe is at elevation 214.0 feet project datum, (elevation 2847.0 feet NGVD).

The low level outlet is a 30-inch diameter CMP conduit on a slope of 0.026 which is controlled at the inlet structure with a 30-inch diameter slide gate. The intake structure could not be inspected because of the reservoir level and the discharge of water prohibited the inspection of the outlet conduit except at the point of discharge. There is no erosion or slumping around the outlet. Due to discharge from the outlet it could not be determined if the pipe was undercut.

The slide gate is operated by means of a gate stem which extends up the face of the dam to a hand wheel mounted at the dam crest. The operator said the gate was hard to close and thought the gate stem could be bent. The gate was not operated during the inspection because of resulting interruption to the irrigation.

The discharge capacity of the outlet and the principal spillway is controlled by the capacity of their common outlet conduit. Assuming the slide gate fully open and the conduit flowing full, the maximum discharge capacity of the outlet with the reservoir elevation at the crest of the dam (elevation 2850.3 feet NGVD) would be 82 cfs.

2.1.3 Freeboard

Because the reservoir reaches the top of the canal bank during the probable maximum flood (PMF; see paragraph 2.2.4), the project has no freeboard. The vertical distance between the low point on the dam and the reservoir level at the time of the inspection was 3.3 feet. The crest of the dam, as determined by field survey, varies 0.6 feet over its 215-foot length. The prevailing winds of the region are from the west or southwest, which would not be directed toward the dam. For winds directed toward the dam from the southeast, the effective fetch for wind-generated waves is about 3000 feet and wave runup on the embankment is estimated to be less than two feet vertically. Although the project has no freeboard during the PMF, the vertical distance between the dam crest and the normal reservoir level is adequate to prevent overtopping the embankment by wind-caused waves.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is continental in nature, characterized by warm summers and cold winters. The nearest climatological station (elevation 2532 feet NGVD) is Eureka Ranger Station about 1½ miles west of the center of the basin; however, only 16 years of records are available and those are incomplete. A climatological station is also located at Kalispell (Glacier International Airport) about 60 miles southeast of the basin at elevation 2965.0 feet NGVD, which has 76 years of record. Mean annual precipitation at the Kalispell station is 16.2 inches with 27 percent falling in the heaviest precipitation months of May and June. Mean February precipitation is 0.97 inches. Mean annual precipitation at the center of Costich Dam drainage basin is approximately 16 inches. Mean annual temperature at Kalispell is 41.8° Fahrenheit (F), mean January temperature is 19.1° F, and mean July temperature is 64.3°F. May and June temperatures average 50.9 and 57.0°F respectively. Temperatures in the Costich Dam basin would be well represented by the Kalispell climatological station. Summer temperatures rarely exceed 95°F, and winter temperatures can reach 25 to 30 degrees below 0°F. Winters have few extended extreme cold spells due to periods of warm "chinook" winds.

The drainage basin area for Costich Dam is 0.50 square miles and is generally oval shaped (plate 2). It is located in the Tobacco River Valley

amid gently rolling grassed covered hills. All of the basin is grass covered and used as grazing land. There are no USGS stream gages in the basin.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 48 acres and a storage of 570 acre-feet at the dam crest elevation 2850.3 feet NGVD. Approximately 154 acre-feet of surcharge storage is available in the reservoir between the principal spillway crest and the dam crest. The principal spillway discharge with the reservoir at the dam crest is 82 cfs, about 6.8 acre-feet per hour.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. An estimate of the PMF was made during this dam safety analysis and was routed through the reservoir.

The probable maximum precipitation (PMP) was developed using procedures contained in the U.S. Weather Bureau's Hydrometeorological Report No. 43 (Reference 5) as updated by U.S. Weather Bureau memorandum dated September 20, 1967 (Reference 6). The thunderstorm PMP produces 9.80 inches of rain in six hours and the general storm produces 12.1 inches in 72 hours. A minimum loss rate of 0.15 inches per hour was assumed to represent the hydrologic class B soils in the basin and minimum infiltration conditions due to saturated ground. Baseflow was considered to be 10 cfs and snowmelt was not used in computation. The thunderstorm PMP produces the most critical flood for the basin since a significant portion of the general storm PMP would be lost to infiltration.

A triangular unit hydrograph for a 6-minute rainfall duration was developed for the 0.42 square mile land portion of the drainage basin using procedures contained in <u>Design of Small Dams</u> (Reference 7). The Soil Conservation Service method of developing a curvilinear fit of the triangular unit hydrograph was used. An incremental hydrograph was also developed for the 0.08 square mile reservoir surface. The hourly increments of the PMP were arranged in a critical time sequence as illustrated in HMR No. 43, page 204, figure 6-1e (Reference 5). The 6-minute increments of the two greatest PMP hours were rearranged in the reverse order of the unit hydrograph to produce the greatest possible peak. The PMP was applied to the unit hydrograph by means of the computer program HEC-1 (Reference 8). This estimate of the PMP produced a flood with a peak flow of 3,330 cfs and a volume of 248 acre-feet.

2.2.4 Flood Routing

Routing of the probable maximum flood through Costich Reservoir was performed using the computer program HEC-1 Flood Hydrograph Package (Reference 8). The reservoir was assumed to be at the principal spillway elevation of 2847.0 NGVD at the beginning of the PMF. The 30-inch diameter

outlet gate was assumed to be completely opened in the analysis. It was assumed that during the PMF, flow from Glen Lake and direct runoff to the main canal would cause the canal to flow full. For the routing analysis the main canal was assumed to contribute no inflow to the reservoir nor provide additional reservoir discharge capability. The routing shows that the dam will not be overtopped during the PMF; however, the main canal embankment, which functions as a dike along the west side of the reservoir, will be overtopped when 31 percent of the total flood volume has entered the reservoir.

Routings were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the project can control. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 35 percent of the PMF ordinates is just controlled by the project. Larger floods would overtop the Glen Lake canal embankment.

2.3 GEOTECHNICAL EVALUATION

The following geotechnical evaluation is based solely on visual field inspection of the geometry and surface materials of the Costich Dam. Existing information does not include a record of embankment construction techniques, compaction, or materials testing.

2.3.1 Dam and Main Canal Dike

Costich Dam is 215 feet long and approximately 24 feet high. The embankment consists of glacial till (sandy, silty clay) placed as a homogenous embankment; however, a second zone of homogenous embankment has been placed on the downstream slope to an elevation 4.0 feet below the crest of the original embankment (plate 4). Strictly defined, the dam consists of a composite embankment of similar homogenous materials derived from the sandy, silty clay till (plate 4). The crest of the original 24-foot high structure ranges from 8 to 10 feet wide.

The added embankment on the downstream slope of the original embankment forms a bench ranging from 20 to 26 feet wide at a height of 17 to 20 feet above the downstream invert of the outlet conduit. The purpose of the added embankment is to provide a bench across the length of the downstream face of the dam to support a small irrigation ditch which diverts water from the main canal and crosses Costich Dam from west to east (see sectional elevation on plate 4). Borrow materials for both sections of the composite embankment were apparently obtained primarily from the glacial till deposits on the west (left) abutment as evidenced by remnants of the excavated hillside.

The downstream face of the new fill slopes at 1V on 2H. The 4 to 7-foot height of the original embankment exposed above the added fill on the downstream face ranges in slope from 1V on 2.6H to about 1V on 3H. All but the uppermost three feet of the upstream face of the embankment was inundated at the time of the inspection; however, point elevations measured under the water surface on the upstream face 13 and 21 horizontal feet from the dam crest indicated slopes of 1V on 2.7H and 1V on 3H, respectively, on the upper seven feet of the embankment. The Soil Conservation Service plans call for a 1V on 4H upstream face slope (Plate 4).

The upstream and downstream slopes of Costich Dam consist of homogenous embankment material not protected by a shell or by riprap. There is no evidence of differential settlement, misalignment, sloughing, creep, accelerated erosion, or slope failure on the embankment. Old animal burrows that are evidently abandoned are present in both the upstream and downstream slopes. The embankment is heavily vegetated with grass and noxious weeds. Sagebrush is present as a dense growth on the downstream face of the newer portion of the embankment and one large clump of brush is growing on the face of the newer embankment near the contact with the right abutment.

Approximately 1030 feet of the main canal from Glen Lake acts as a dike along the west side of the Costich Reservoir (plate 4). The main canal embankment averages about 30 feet in width including the channel and a dike on each side. The trapezoidal canal contained in the middle of the dike has a bottom width of about 15 feet and width of about 22 feet at the crest of the dike. The average width of the dike crest on each side of the canal is about four feet although local variations in crest width due to the canal running off of the centerline range from 3 to 10 feet. The maximum height of the main canal dike is about 7.5 feet and the slope of the downstream face (the side opposite Costich Reservoir) ranges from 1V on 2H to 1V on 3.5H.

The main canal dike is generally regular and even and does not exhibit signs of excessive erosion or displacement due to slumping or other shear failure. The dike borrow material was obtained from the glacial till deposits along the canal route. The reservoir side of the dike is not protected by riprap or other material and appears to be somewhat steepened by wave erosion. The dike is vegetated with grass except on the reservoir side where dense growths of wild rose bush and other types of brush cover the face and provide a certain amount of protection against wave erosion. A few muskrat burrows are present, especially on the reservoir side of the dike; however, none of the burrows appear to tunnel completely through the dike into the main canal.

2.3.2 Foundation Conditions, Seepage, and Drainage

The foundation at the main Costich Dam embankment consists of glacial till. The extent of foundation preparation is unknown except for the reference to a 3-foot deep cutoff trench shown on the plans (plate 4). Inspection of the main embankment did not reveal evidence of seepage in the foundation, abutments, or embankment. There was no evidence of a wetting front or seepage in the main embankment despite the presence of the previously described irrigation ditch conveying water across the top of the newer part of the dam. The ditch carries water to one user and flows during the irrigation season only. The degree of saturation of the embankment materials and the associated effects on potential embankment stability could not be determined by visual inspection. The discharge from the outlet conduit prevented inspection of the underside of the conduit for external seepage parallel to the conduit.

The foundations of the main canal also consists of glacial till. The downstream slope of the canal dike exhibits evidence of seepage near the toe of the dike from about Station 9+25 to Station 10+25 (plate 3). This area had very wet soil at the surface and was vegetated with sedge grass. The only seepage water observed was at the toe of the dike and was clear water. The seepage appeared to be confined mostly to the natural ground, i.e., the glacial till foundation under the dike and was possibly moving through the pedological soil zone at the top of the till foundation.

2.3.3 Stability

Study of the available information does not provide any suggestion of instability in the main Costich Dam embankment. However, despite the absence of external evidence of instability, the available information is insufficient for evaluation of embankment stability of either the Costich Dam or the main canal embankment.

2.4 PROJECT OPERATION AND MAINTENANCE

The facility is owned and operated by the Glen Lake Irrigation District. Information on operations and maintenance was obtained from a discussion with Mr. Vanleishout.

2.4.1 Dam

There is no periodic maintenance plan for the dam and no other inspections of the dam are on record. No major maintenance of the dam has been required to date.

2.4.2 Reservoir

Costich Dam and Reservoir is part of the total Glen Lake Irrigation Project. Inflow to Costich Reservoir is controlled by releases from Glen Lake through the main canal and by the siphon capacity on the main canal which crosses St. Clair Creek. At Costich Dam releases are controlled by the low level outlet. During the irrigation season Costich Dam is visited at least daily by the ditch rider to regulate releases. Discharges from Costich Reservoir are handled entirely within the irrigation conveyance system. No flows are discharged to the natural drainage downstream.

During the winter and spring, the reservoir is filled from Glen Lake and then the supply canal is shut off. Main canal flows to Costich Reservoir can be diverted around Costich Dam by operating turnouts in the canal.

2.4.3 Warning Plan

There is no formal warning plan in use in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

The 24-foot high Costich Dam impounds 570 acre-feet of water with the reservoir at the crest of the dam and 470 acre-feet with the reservoir at the top of the main Glen Lake canal embankment. In accordance with the recommended guidelines (Reference 1), the project is classified as small in size and has a high (category 1) downstream hazard potential rating. Guidelines recommend a dam of this size and hazard classification be capable of safely handling a flood in the range of one-half the PMF to the full PMF. Because of high risk to inhabitable structures downstream, the recommended spillway design flood (SDF) for this project is the full PMF.

The project can handle a flood with a hydrograph having ordinates corresponding to 35 percent of the PMF ordinates before the main canal at the west dam abutment is overtopped. When the canal is overtopped at this location the dam abutment could erode and the stability of the dam is threatened. If the canal overtops at the second reach, approximately 750 feet from the dam, the canal embankment would fail and release water down a drainage west of the reservoir. Water released down the west drainage could cause loss of life at a house in the bottom of the ravine and then flow into the Costich Dam drainage upstream of Eureka. The safety of the project is therefore evaluated with regard to the overtopping condition of the main canal rather than overtopping of the dam. Because of the low canal embankment, the dam is not overtopped by the PMF. Because the project is incapable of controlling one-half the PMF without overtopping the canal embankment and causing the dam or the canal to fail, Costich Dam Project does not conform to inspection guidelines.

3.1.2. Embankment

The Costich Reservoir is impounded by an earthfill embankment dam and limited reaches of a main supply canal embankment located along the west edge of the reservoir. Visual inspection of the dam embankment revealed no longitudinal or transverse cracking. The downstream slope of the dam was not as indicated on design drawings. An additional embankment has been placed on the downstream slope of the dam approximately 4 to 7 feet below the crest of the dam. The additional embankment creates a 20 to 26-foot wide bench which supports a small irrigation ditch across the face of the dam. There are no piezometers in the embankment and there is no indication of seepage or a wetting front despite the presence of the flowing ditch. Although there is insufficient information available with which to evaluate embankment stability there is no significant external evidence of instability and it is judged that stability may conform to inspection guidelines.

The dam is clear of trees and brush growth is limited to small sagebrush. The pool level at the time of inspection was 3.3 feet below the dam crest which corresponds to the principal spillway elevation 2847.0 NGVD. There is no evidence of wave erosion on the upstream slope of the dam and wave action would not be directed at the dam by prevailing winds.

The Glen Lake canal embankment along portions of the west shore of the reservoir shows no signs of displacement or instability. Some clear seepage was noted at the downstream toe of the canal embankment (second reach) but appeared to be confined to foundation material. Some erosion of the embankment slope on the reservoir side has occurred but the bank is protected to some degree by the presence of rose bushes and brush.

3.1.3 Spillway and Reservoir Capacity

The reservoir has a surface area of about 44.1 acres and a storage capacity of 416 acre-feet at the principal spillway crest, elevation 2847.0 feet NGVD. Approximately 54 acre-feet of surcharge is available in the reservoir between the principal spillway crest and the top of the canal embankment. Approximately 154 acre-feet of surcharge storage would be available between the crest of the principal spillway and the crest of the dam if the water could reach this level. The combined discharge of flow over the canal embankments and the principal spillway with the reservoir at the dam crest, is 2100 cfs. There is no emergency spillway for the project.

3.1.4. Outlet Works

The outlet works are operated regularly by the ditch rider during the irrigation season. The conduit and inlet structure could not be inspected due to the pool level and irrigation discharges. The operator indicated the gate contol is difficult to operate and the gate stem might be bent.

3.1.5. Operations and Maintenance

Costich Dam and Reservoir are operated as an off-stream storage and regulating facility and are part of the Glen Lake Irrigation Project. The reservoir has a very small drainage area and is supplied by a main canal from Glen Lake. The reservoir is controlled by diversion from the canal and by releases through the outlet works. The reservoir is usually filled in the winter and spring and held at that level for the irrigation season. Routine maintenance and inspections are not performed on the dam, canal or outlet works. There is no formal downstream warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to storage between normal pool and canal dike crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this flood protection.

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of impending embankment overtopping or structural failure.

2. Remove the few scattered trees, root systems, and large brush from the canal embankment and toe areas. Backfill and compact all depressions, including animal burrows.

3. Inspect the low-level outlet gate and conduit and repair as required.

4. Make an assessment of the phreatic surface through the embankments and their foundations by drilling and installing piezometers. Perform and place on file slope stability analyses of the critical sections. These analyses should be conducted by a qualified geotechnical engineer and be based on actual phreatic surface and strength characteristics as determined from piezometer drilling and sampling. Modify the embankment sections as required for stability.

5. Provide a trash rack (grate) with additional surface area and suitable mesh size which will not severely limit the capacity of the principal spillway if it becomes partially clogged.

6. Provide riprap protection to the dam in areas which could be threatened during overflow from the main canal.

7. Prepare and implement a formal operating and maintenance plan.

8. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and spillway requirements, and modify the project as studies indicate.

9. Conduct inspections of Costich Dam at least once every five years by engineers experienced in dam design and construction.

Prior to performing engineering studies and remedial construction, coordination should be undertaken with the Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington D.C., Department of the Army, May 1975.

2. Fenneman, N.M., 1931, Physiography of Western United States: New York, McGraw-Hill Book Co., Inc., 534 p.

3. Johns, W.M., 1970 Geology and Mineral Deposits of Lincoln and Flathead Counties, Montana: Montana Bureau of Mines and Geology Bulletin 79, 182 p.

4. U.S. Department of Army, Corps of Engineers Hydrologic Engineering Center; "HEC-2 Water Surface Profiles", Generalized Computer Program Users Manual with Supplement; Nov. 76.

5. U.S. Weather Bureau, Hydrometeorological Report No. 43, "Probable Maximum Precipitation, Northwest States," Washington, D.C., 1966.

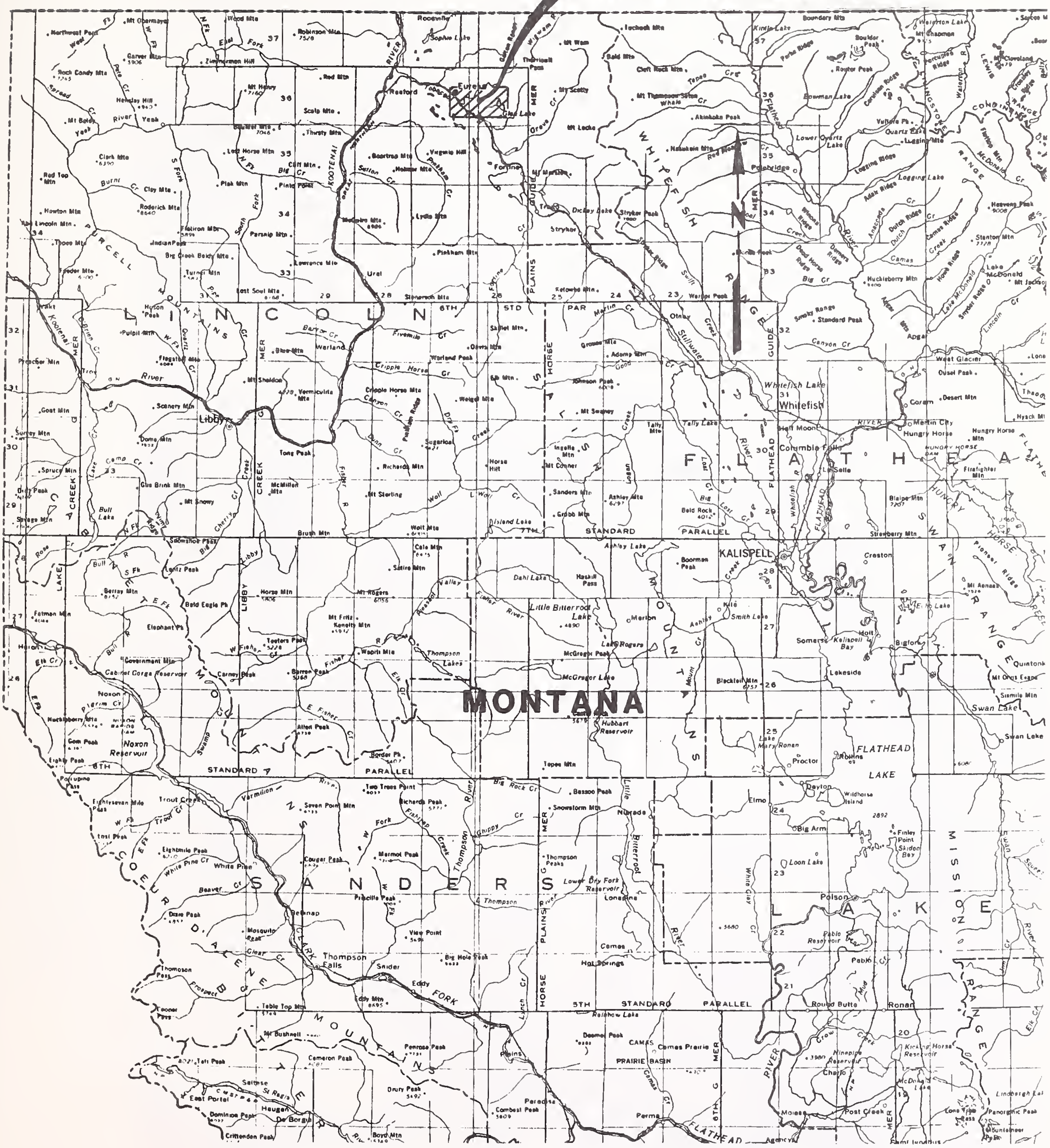
6. Hydrometeorological Branch, U.S. Weather Bureau Office of Hydrology, "Memorandum" Probable Maximum Thunderstorm Rain for the Columbia River Basin East of the Cascade Ridge," 20 September 1967.

7. U.S. Department of Interior, "Design of Small Dams", 3rd ed., Bureau of Reclamation, Denver, Colorado, 1977, 816 pp.

8. U.S. Army Corps of Engineers, Hydraulic Engineering Center, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations", Davis, Calif., Department of the Army 1978, 93.

COSTICH DAM

See Area Map For Exact Location



Scale

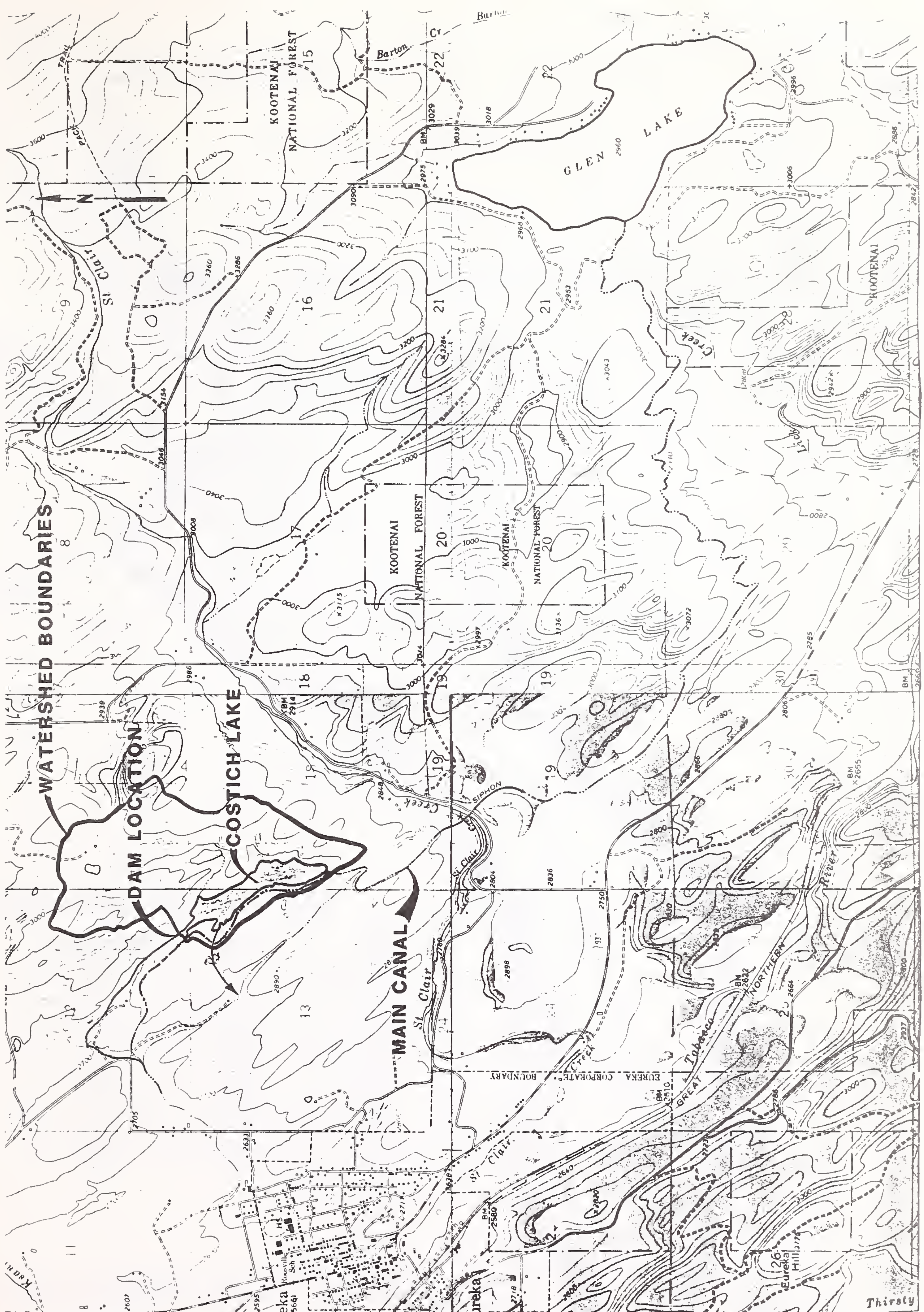
1 inch equals approximately 16 miles

10 0 10 20 30 40 Miles

10 0 10 20 30 40 50 Kilometers

PLATE 1

LOCATION MAP



SOURCE OF BASE: USGS Quadrangles EUREKA NORTH (1963) and KSANKA PEAK (1963)

SCALE

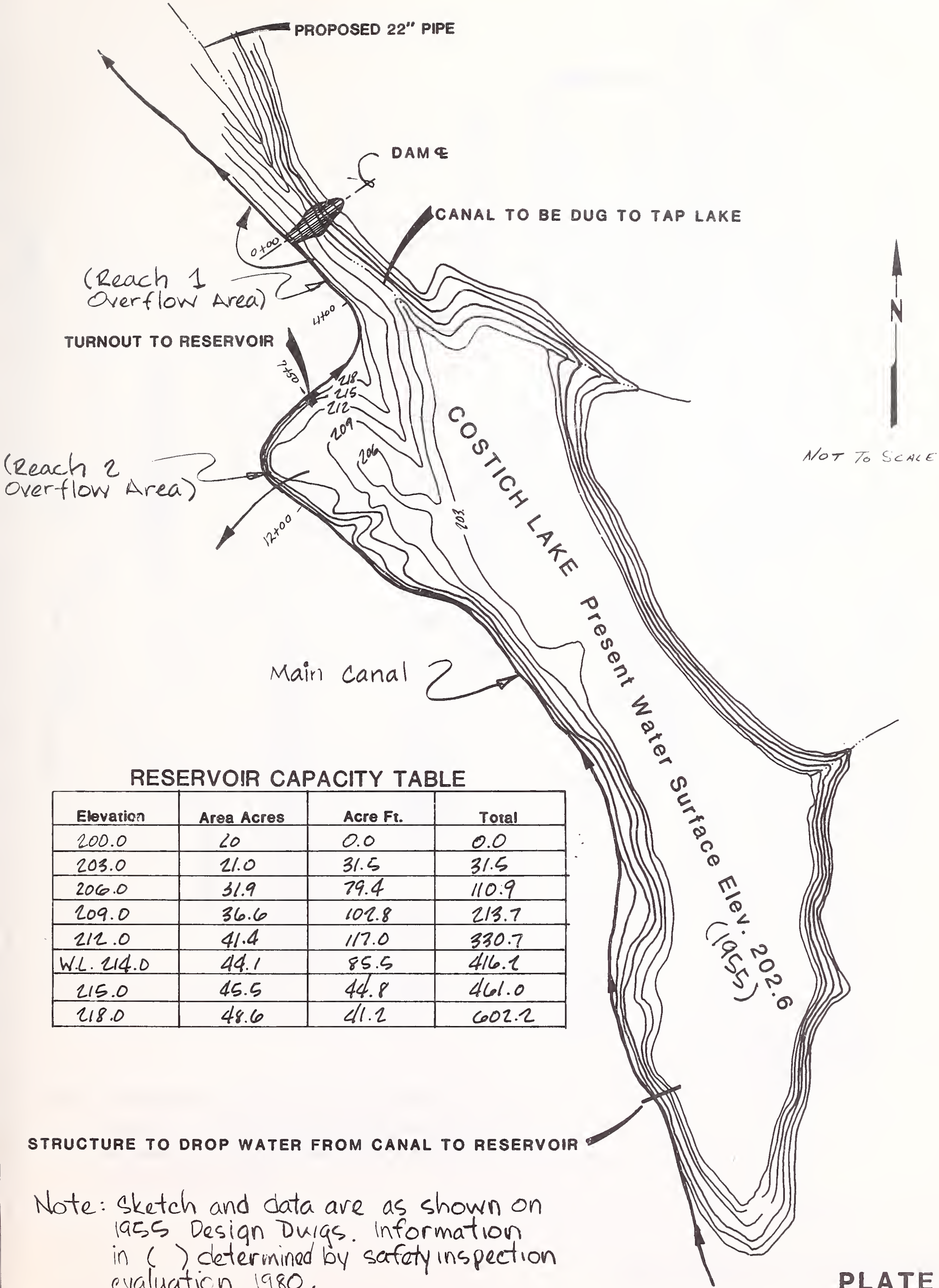
1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETRE

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

PLATE 2
AREA MAP



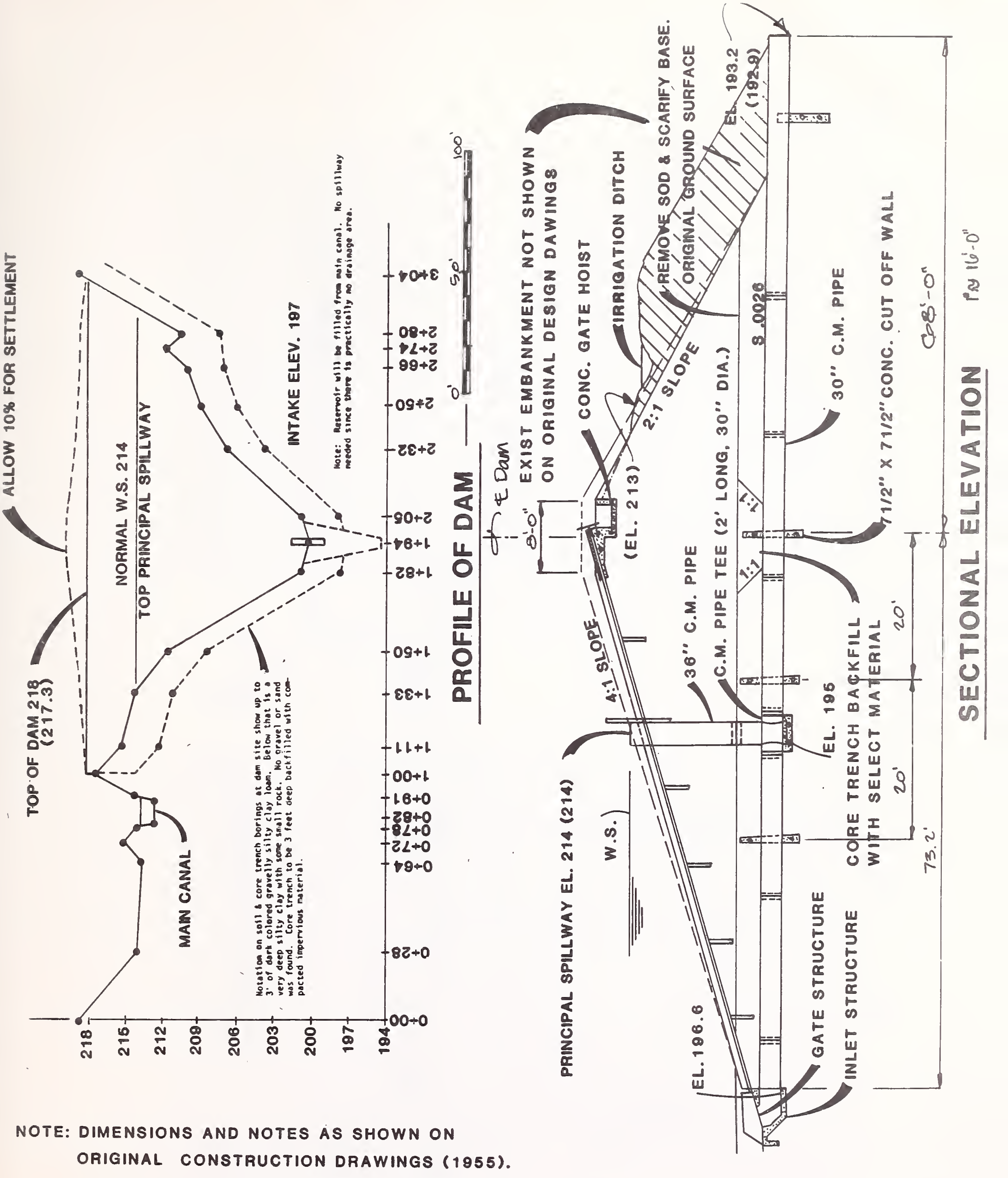
RESERVOIR CAPACITY TABLE

Elevation	Area Acres	Acre Ft.	Total
200.0	20	0.0	0.0
203.0	21.0	31.5	31.5
206.0	31.9	79.4	110.9
209.0	36.6	102.8	213.7
212.0	41.4	117.0	330.7
W.L. 214.0	44.1	85.5	416.2
215.0	45.5	44.8	461.0
218.0	48.6	41.2	602.2

Note: Sketch and data are as shown on 1955 Design Dwgs. Information in ( ) determined by safety inspection evaluation 1980.

PLATE 3

SITE PLAN



NOTE: DIMENSIONS AND NOTES AS SHOWN ON ORIGINAL CONSTRUCTION DRAWINGS (1955). NUMBERS IN () WERE MEASURED DURING INSPECTION (1980).

PLATE 4

DAM PROFILE & CROSS SECTION

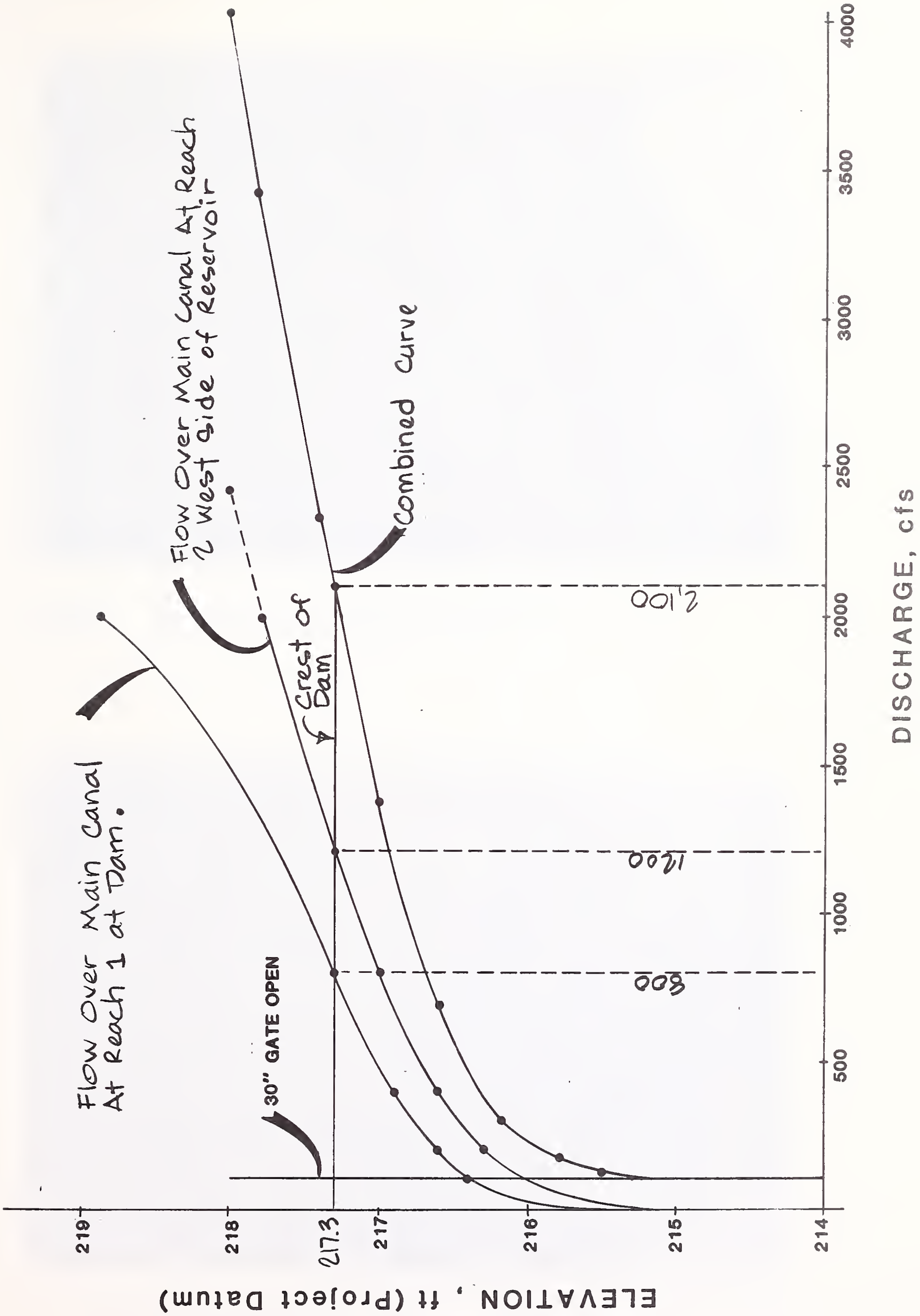


PLATE 5

ELEVATION- DISCHARGE CURVE COSTICH DAM

Photo 1 Aerial view of Dam and Reservoir.

Photo 2 Aerial view of Eureak and Drainage Below Dam.

Photo 3   Downstream Face of Dam and Otlet Canal.

Photo 4   Outlet Canal Downstream of Dam.

Photo 5 Crest of Dam Looking East.

Photo 6 Added Bench on Downstream Face with Irrigation Ditch.
Photo Taken Looking East Across Dam Face.

Photo 7   Upstream Face of Dam Looking West at Main Canal.

Photo 8 View of Main Canal on Left and Reservoir and Upstream Face of Dam on Right.

Photo 9   Main Canal Turnout to Ditch Across Face of Dam. Area of Potential Overflow Around West Dam Abutment.

Photo 10 Overflow Drainage West of Reservoir.

Photo 11 Principal Spillway Inlet.

Photo 12 Outlet Pipe at Point of Discharge.

APPENDIX

Correspondence

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

WATER RESOURCES DIVISION

TED SCHWINDEN, GOVERNOR 32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 ADMINISTRATOR
(406) 449-3962 WATER RIGHTS BUREAU
(406) 449-2872 WATER SCIENCES BUREAU
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HELENA, MONTANA 59620

April 29, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
PO Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Costich Dam (MT-1025). We concur with the findings and recommendations and feel that the report satisfies the criteria for the Phase I evaluation. Minor comments have been discussed with your staff and we understand that these will be included in the final report.

Thank you for this opportunity to review and comment on the final draft report for this project.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau

RB/LT/lz

United States Department of Agriculture
Soil Conservation Service
P.O. Box 970
Bozeman, MT
59715

April 24, 1981

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft report on Costich Dam (MT-1025).

Our comments relating to specific report statements are:

Page 21, Recommendations: The Canal overflow reaches act as spillways. By COE inspection criteria, the only factor making the dam unsafe is the left abutment being threatened during overflow from reach 1. Shouldn't the recommendations indicate that abutment protection is a most important remedy?

We request that the meteorologic and hydrologic assumptions and conditions be fully presented and justified in the report.

We do not feel the meteorologic and hydrologic conditions used to develop the PMF are realistic. The conditions and criteria selected attempt to eliminate the element of risk to a degree that is not reasonable or practical.

We urge that a breach flood routing and thus a substantiated hazard classification be made in the Phase I inspection. With such a brief field overview, general hydrologic modeling and a subjective hazard analysis, the report is forcing the as yet unjustified economic burden of a Phase II inspection on the dam owners.

Sincerely,

Van K Haderlie

Van K Haderlie
State Conservationist

cc:
Ray Smith, State Conservation Engineer, SCS, Bozeman

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Chief Engineer No.	Date Approved
	6-11-81

Project No. 1447-009-04 (33)